Case study on printed matter

Including chemical-related impact categories in LCA on offset printed matter

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SEVENTH FRAMEWORK PROGRAMME

RISKCYCLE

Case study on printed material

Including chemical-related impact categories in LCA on offset printed matter

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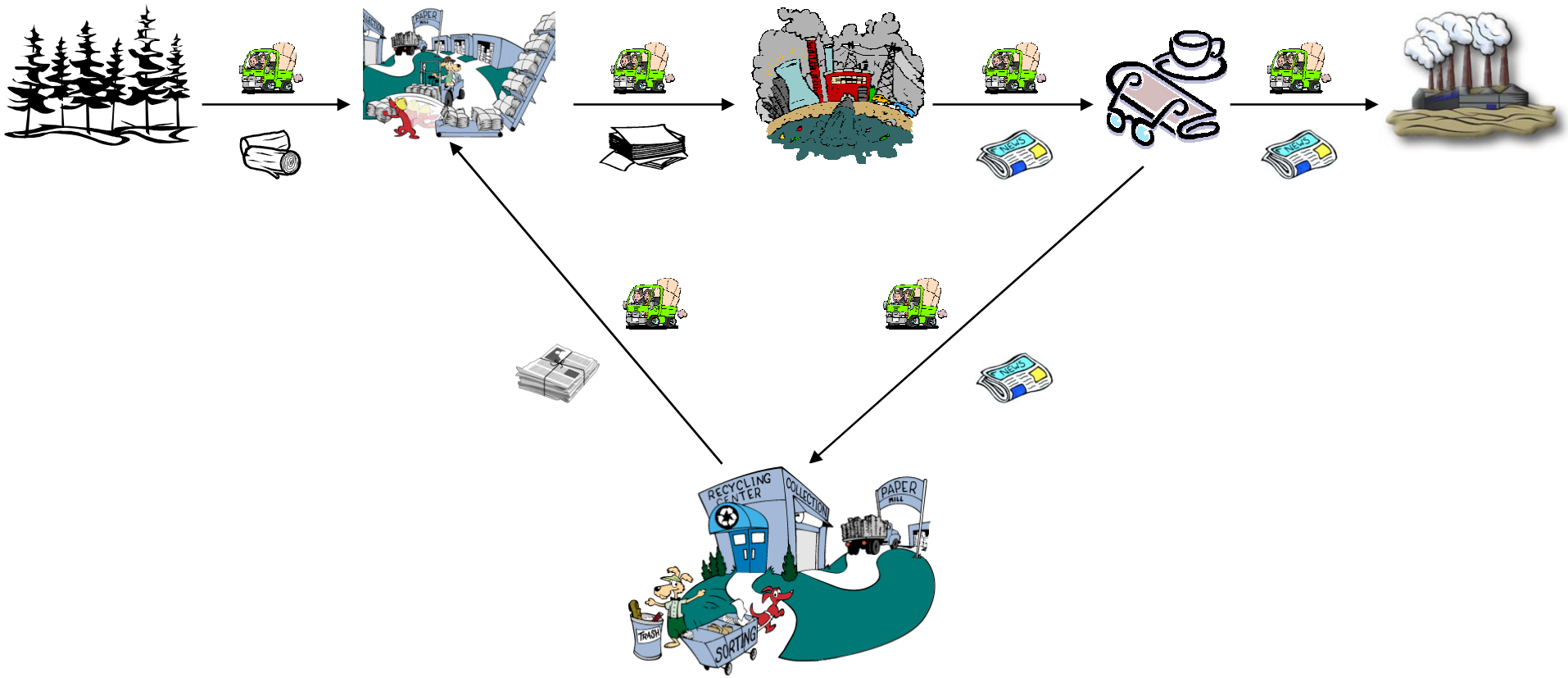
Outline

- The background for this presentation
- The life cycle of printed matter
- The product system for sheet fed offset printed matter
- What is product life cycle assessment (LCA)
- Results of the LCA study on printed matter. Does it matter whether or not we include toxic effects of chemical emissions
- Conclusions and further research
- Literature references

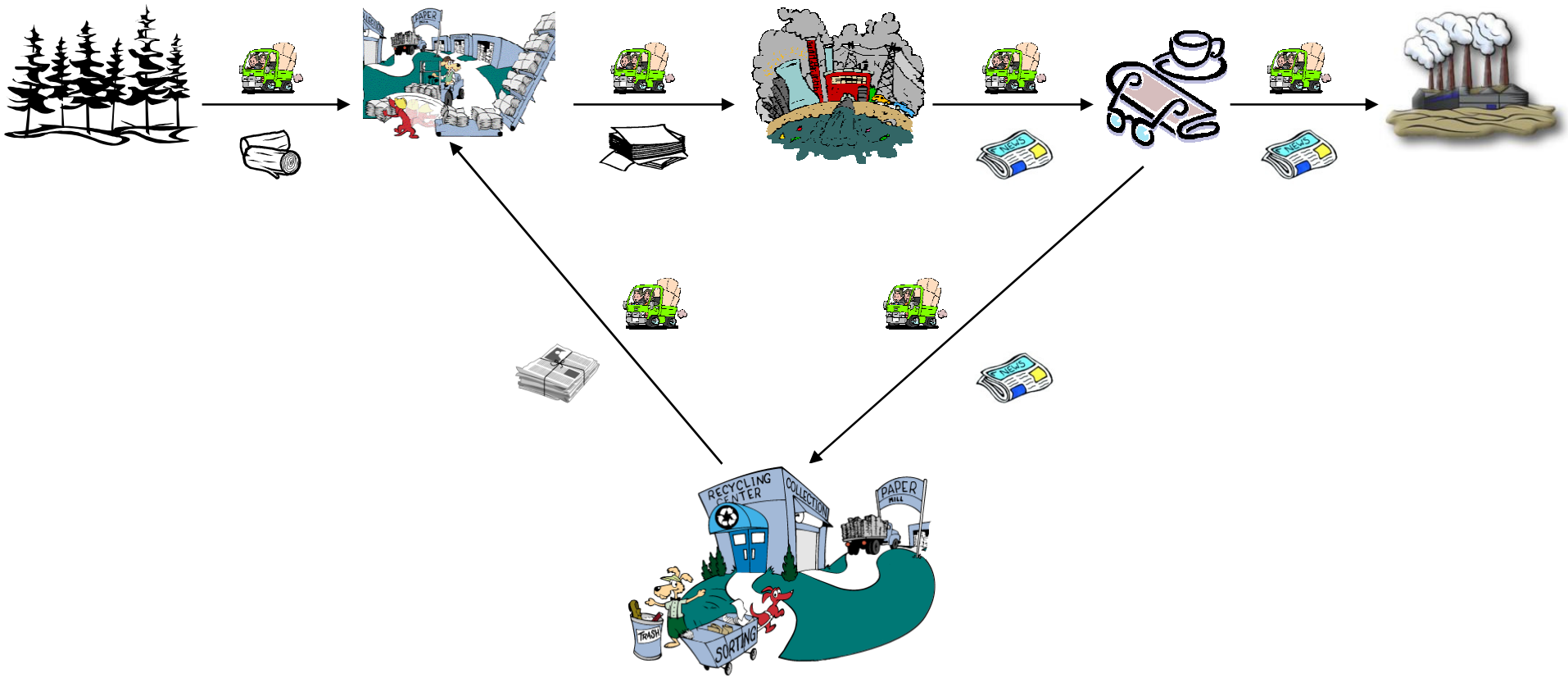
This presentation is based on the following work:

- A Danish project on Ecolabelling of printed matter
  - **Partners:** The Graphics Association of Denmark (GA), IPU, and the Technical University of Denmark (DTU).
  - **Financed by:** The Danish EPA and the Danish Agency for Development of Trade and Industry
  - **Timeframe**: May 2003 – May 2004
  - **Purpose**: Analyze the existing Scandinavian Swan label criteria for printed matter from an LCA perspective and produce a well founded basis for revision of the Swan label criteria and the coming European Union Flower label criteria
- The PhD dissertation "Assessment of chemical emissions in life cycle impact assessment" (Larsen 2004)
- The paper: "Life-cycle assessment of offset printed matter with EDIP97 – how important are emissions of chemicals? " (Larsen et al. 2009)

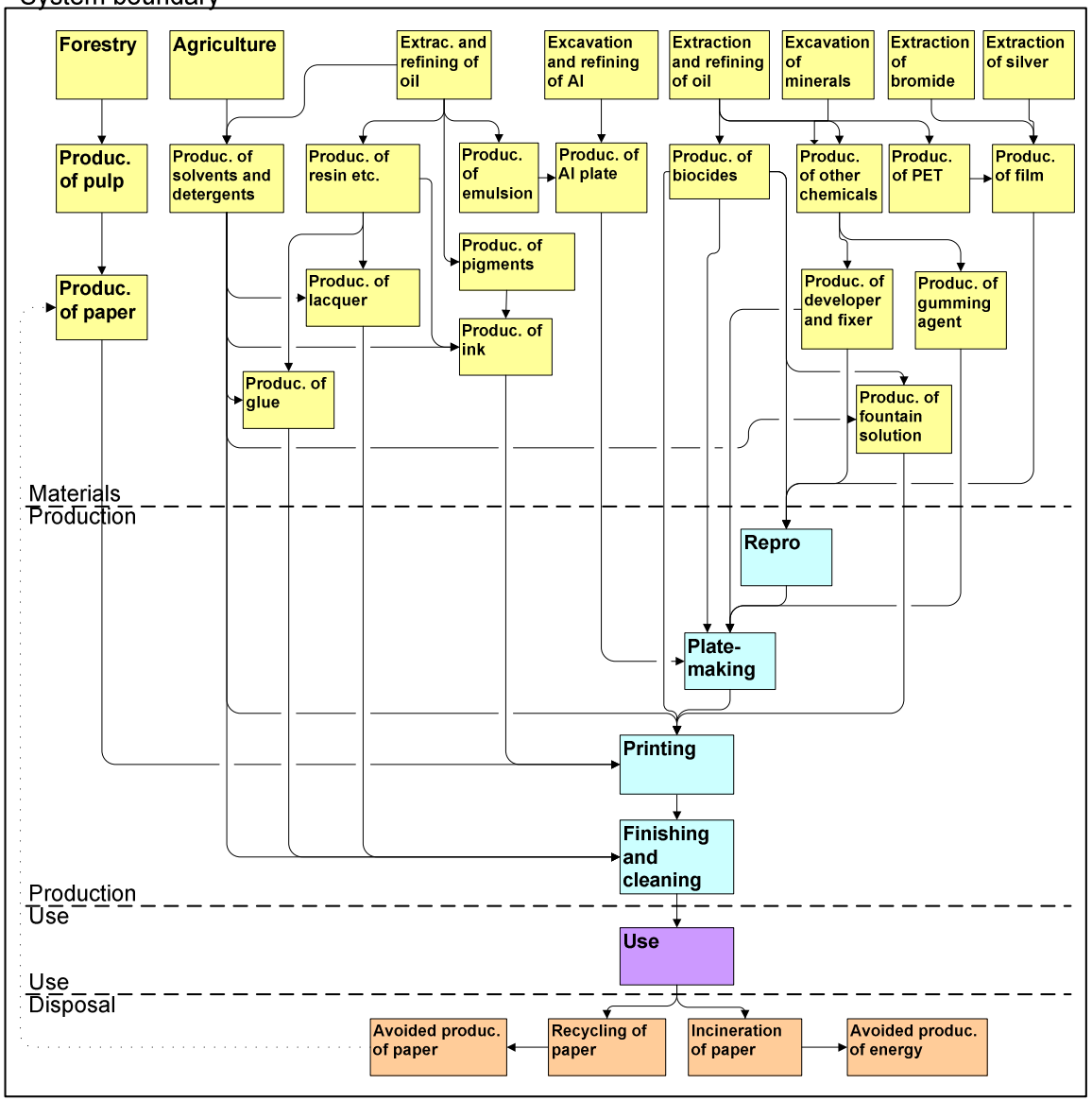
The life cycle of printed matter



The life cycle of printed matter



System boundary

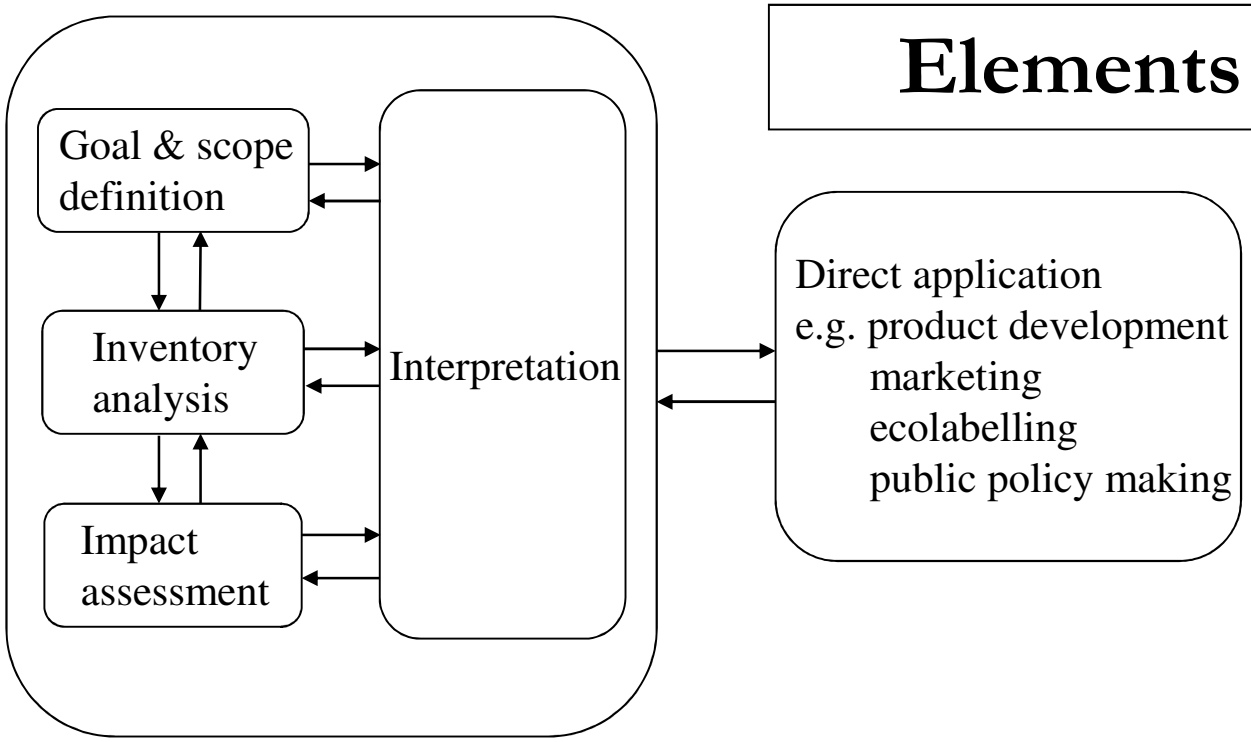


What is Life Cycle Assessment, LCA?

Characteristic features of LCA are:

- A decision supporting tool
- Focus on services typically represented by a product (the "functional unit") This study: 1 ton printed matter
- Comparative (relative statements). This study: Distribution of relative impacts from emissions and resource consumption during the life cycle
- Holistic perspective
  - life cycle from cradle to grave
  - all relevant environmental impacts This study: Global warming, acidification, ecotoxicity……
  - resource consumption (biotic and abiotic) This study: Kaolin, Al, Ag, coal….
- Aggregation over time and space
  - life cycle is global
  - life cycle may span over decades or even centuries

Elements of LCA



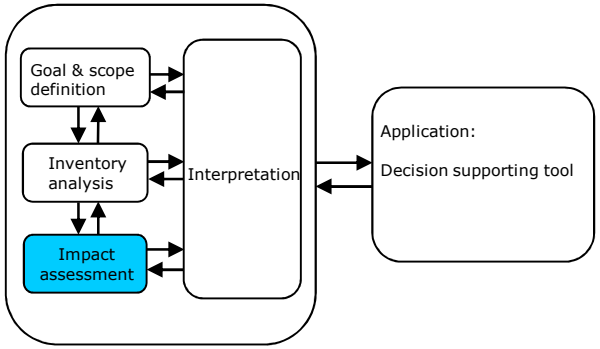
Goal and Scope definition

- defining goal: This study: Identify the distribution of potential impacts… defining the product system: This study: See figure
- decisive for interpretation and use of results: This study: Model, ecolabelling, chemical related impact categories included

Inventory analysis (LCI)

- collecting in- and output data for all processes: This study: See Figure

Life cycle impact assessment (LCIA)



Classification: *"What does this emission contribute to?"*

- Assignment of emissions to impact categories according to their potential effects
  - Global warming (e.g. CO_2, CH_4)
  - Acidification (e.g. NO_2, SO_3)
  - Ecotoxicity (e.g. pharmaceuticals, heavy metals)
  - Human toxicity (e.g. benzene, PAH's)
  - ……..

Characterisation: *"How much may it contribute?"*

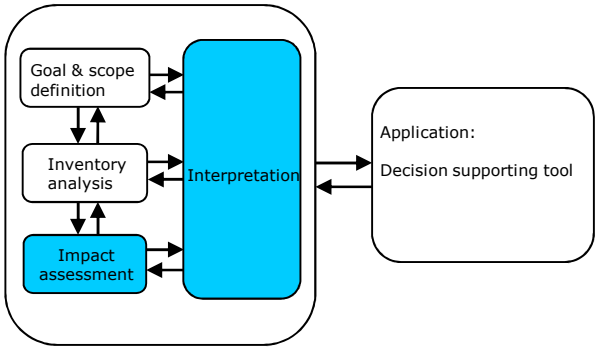
- Quantification of contributions to the different impact categories by estimating impact potentials, IPs (e.g. multiplying the characterisation factors (CFs) for each chemical by the emitted amount (Q) per functional unit (fu):

$$IP = Q*CF$$

- Example (GWP):

Substance	Q (g/fu)	CF (g CO_2-eq/g)	IP (g CO_2-eq/fu)
Carbon dioxid (CO_2)	250	1	250
Methane (CH_4)	10	25	250
Total			500

Life cycle impact assessment (LCIA) and interpretation



Normalisation: *"Is that much?"*

- Expression of the impact potentials relative to a reference situation (person-equivalence, PE), e.g. normalisation reference (NR) for GWP: 8,700 kg CO_2-eq/pers/year. The normalised impact potential (nIP):

$$nIP = IP/NR$$

Impact category	NR (kg CO_2-eq/pers/year)	IP/fu (kg CO_2-eq/fu)	nIP (mPE/fu)
Global warming (GWP)	8700	0,5	0,057

Valuation: *"Is it important?"*

- Ranking, grouping or assignment of weights (weighting factors, WFs) to the different impact potentials (EDIP: political reduction targets), e.g. for global warming a targeted 10 years reduction of 20% => WF=1/(1-0.2) = 1.3. The weighted impact potential (wIP):

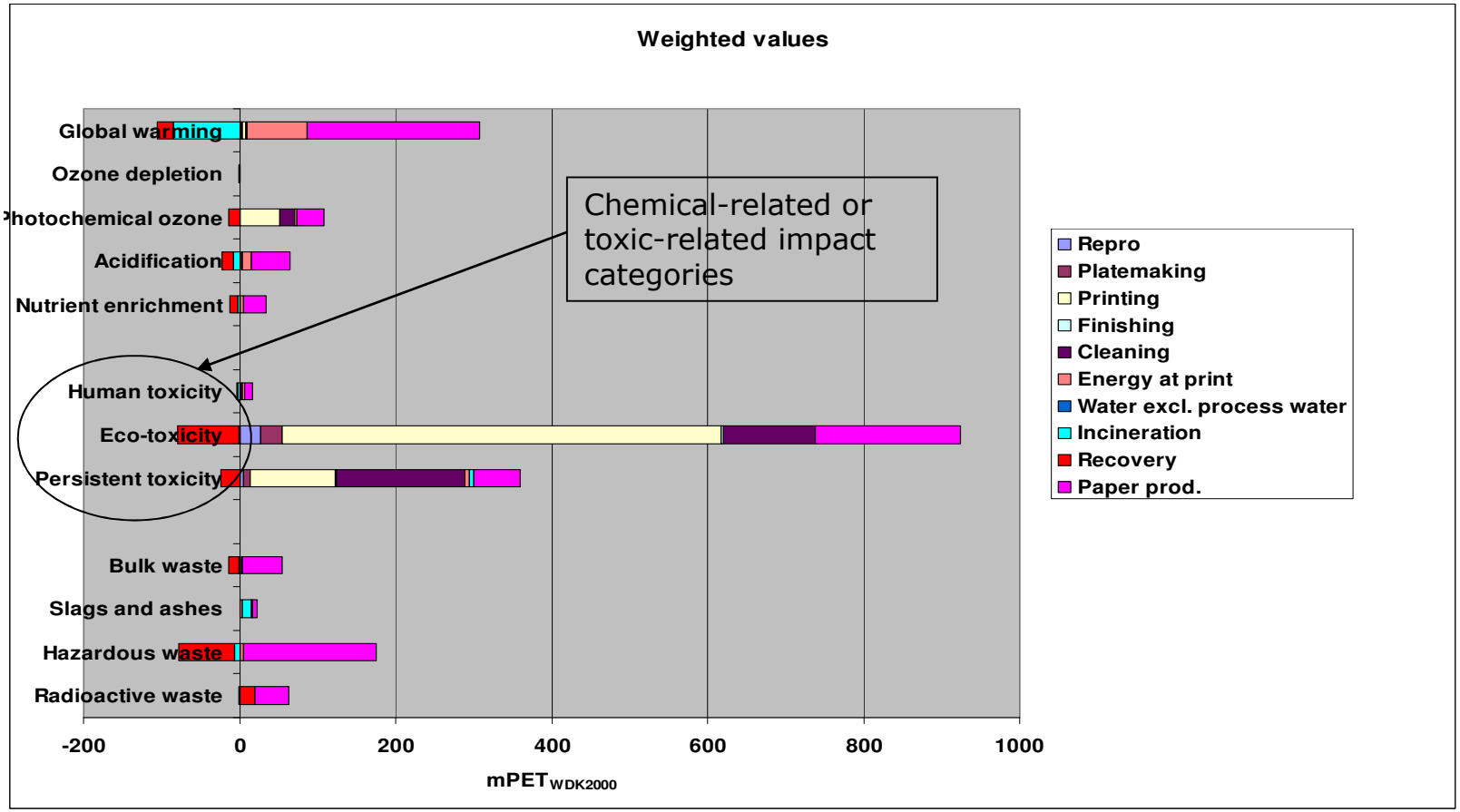
$$wIP = nIP*WF$$

Impact category	WF	nIP (mPE/fu)	wIP (mPET/fu)
Global warming (GWP)	1,3	0,057	0,074

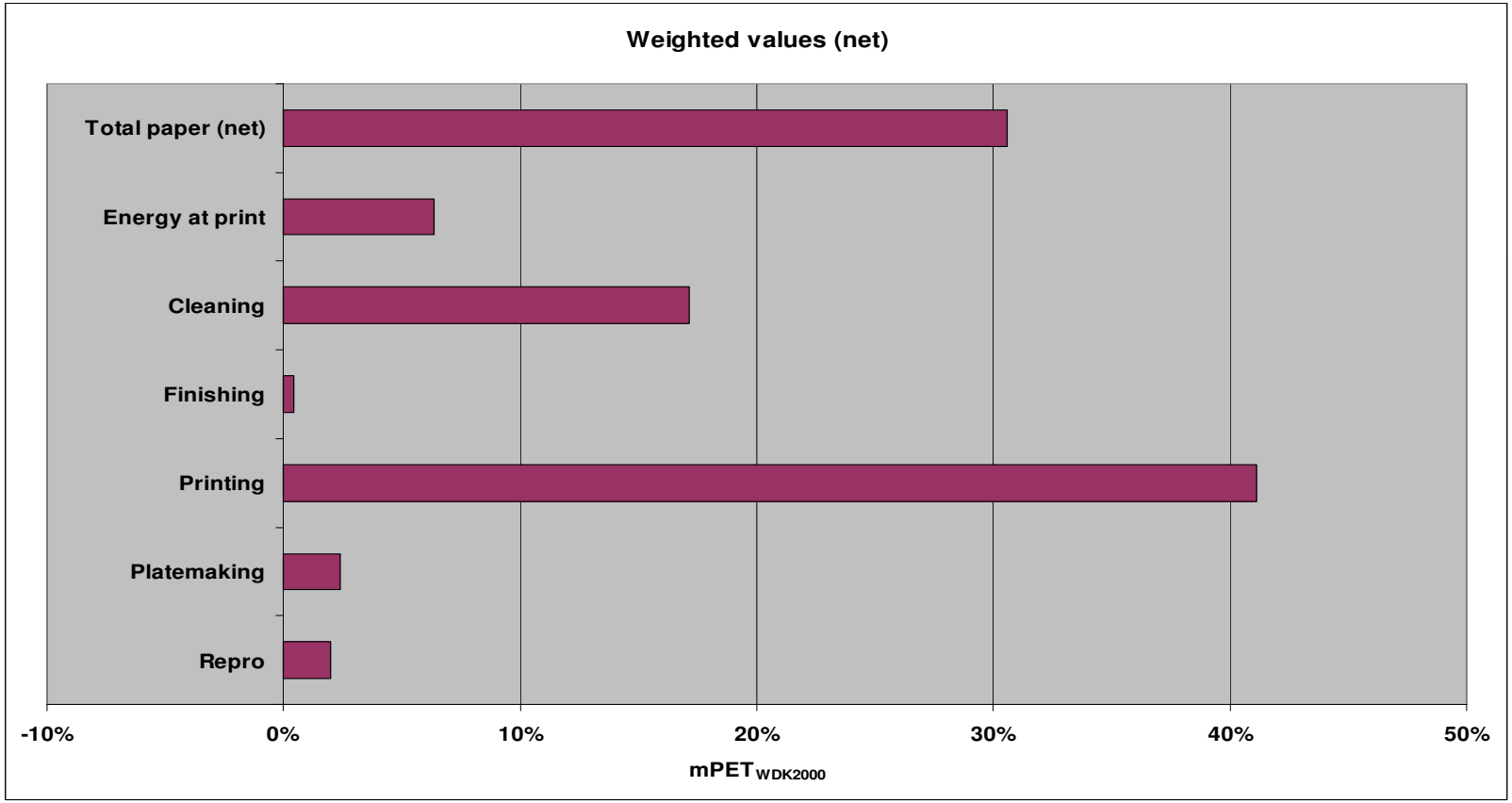
Interpretation: *"Where is the hotspots in the life cycle and for what reason?"*

- Is paper production a hotspot for printed matter life cycle? Due to energy consumption?

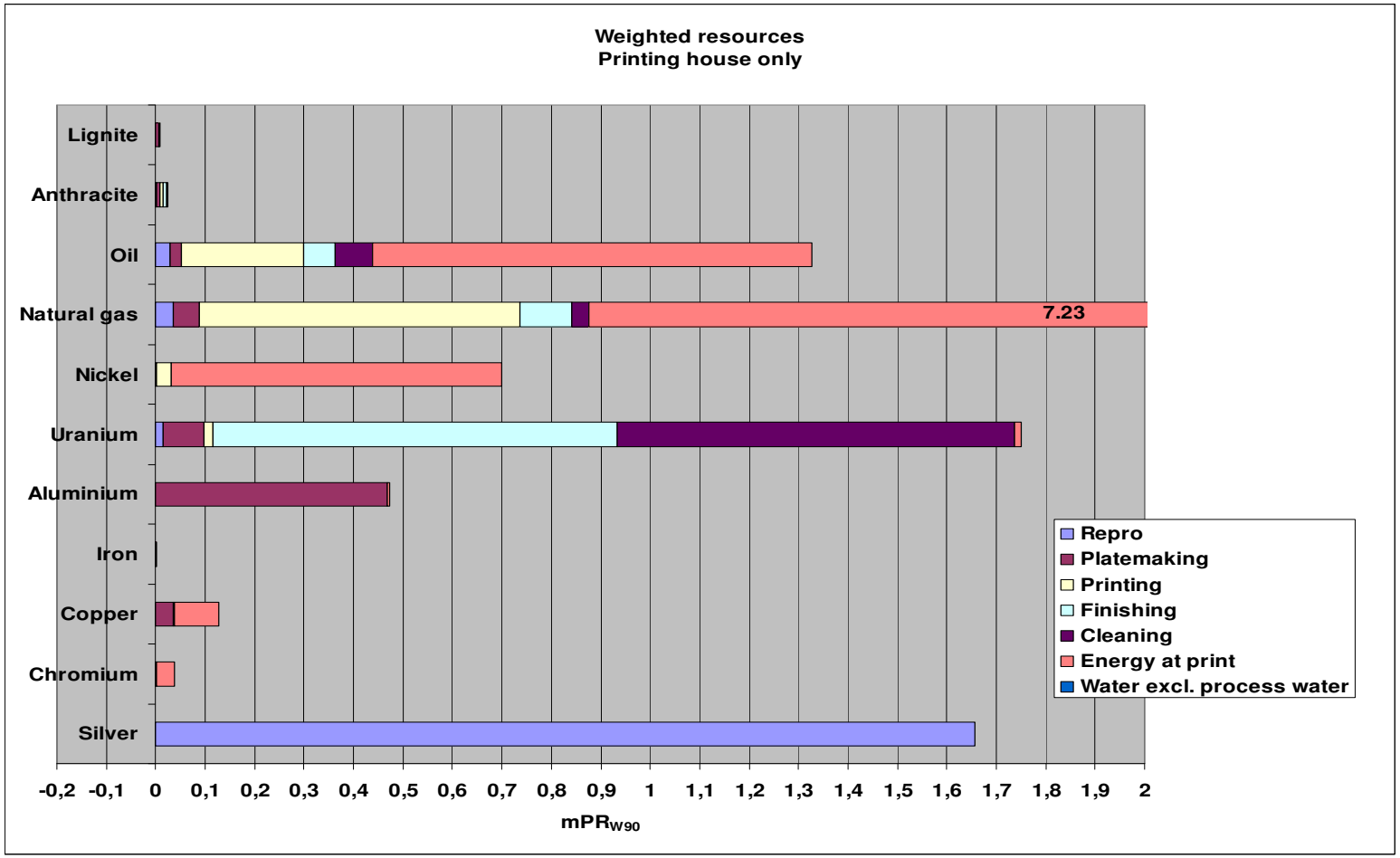
Results
Distribution of potential environmental impact



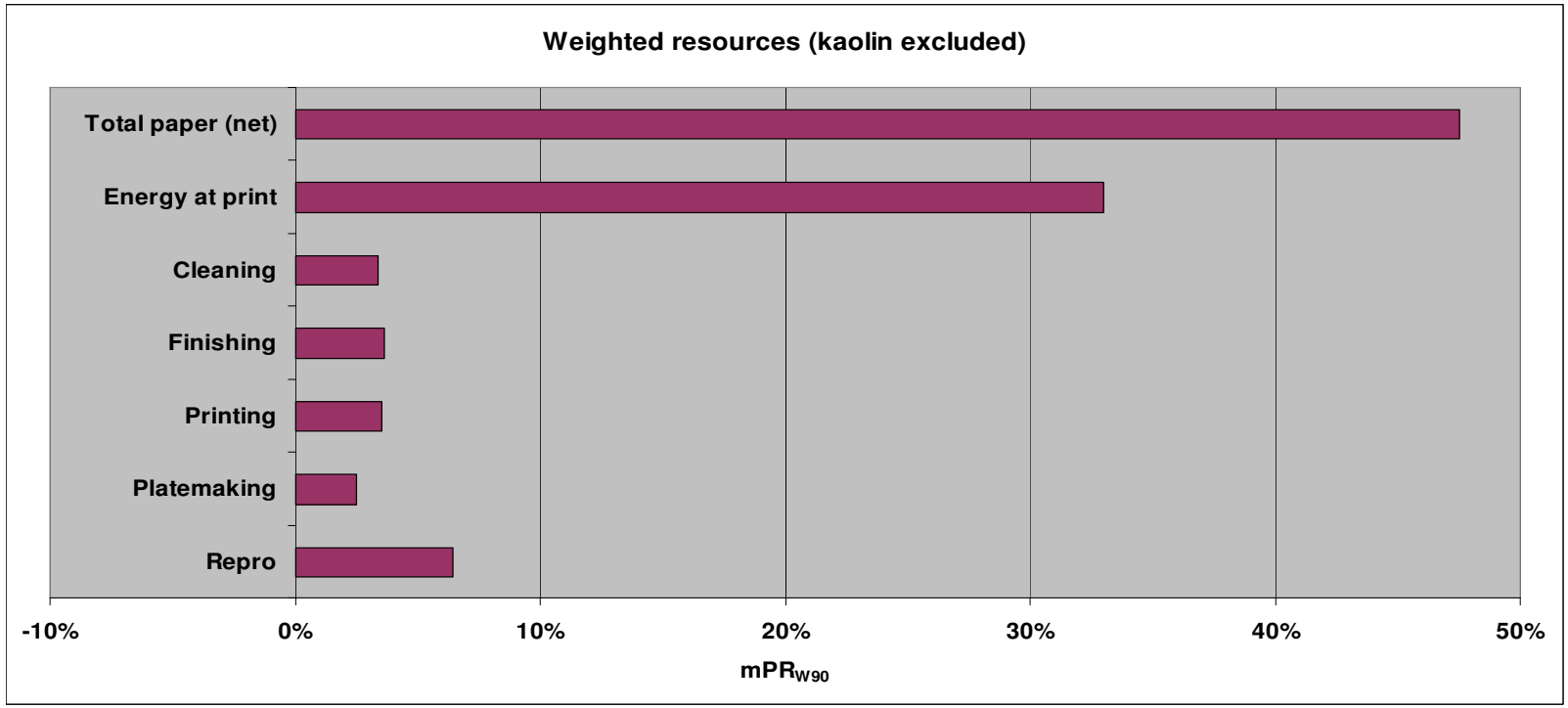
Results
Relative distribution of potential environmental impact



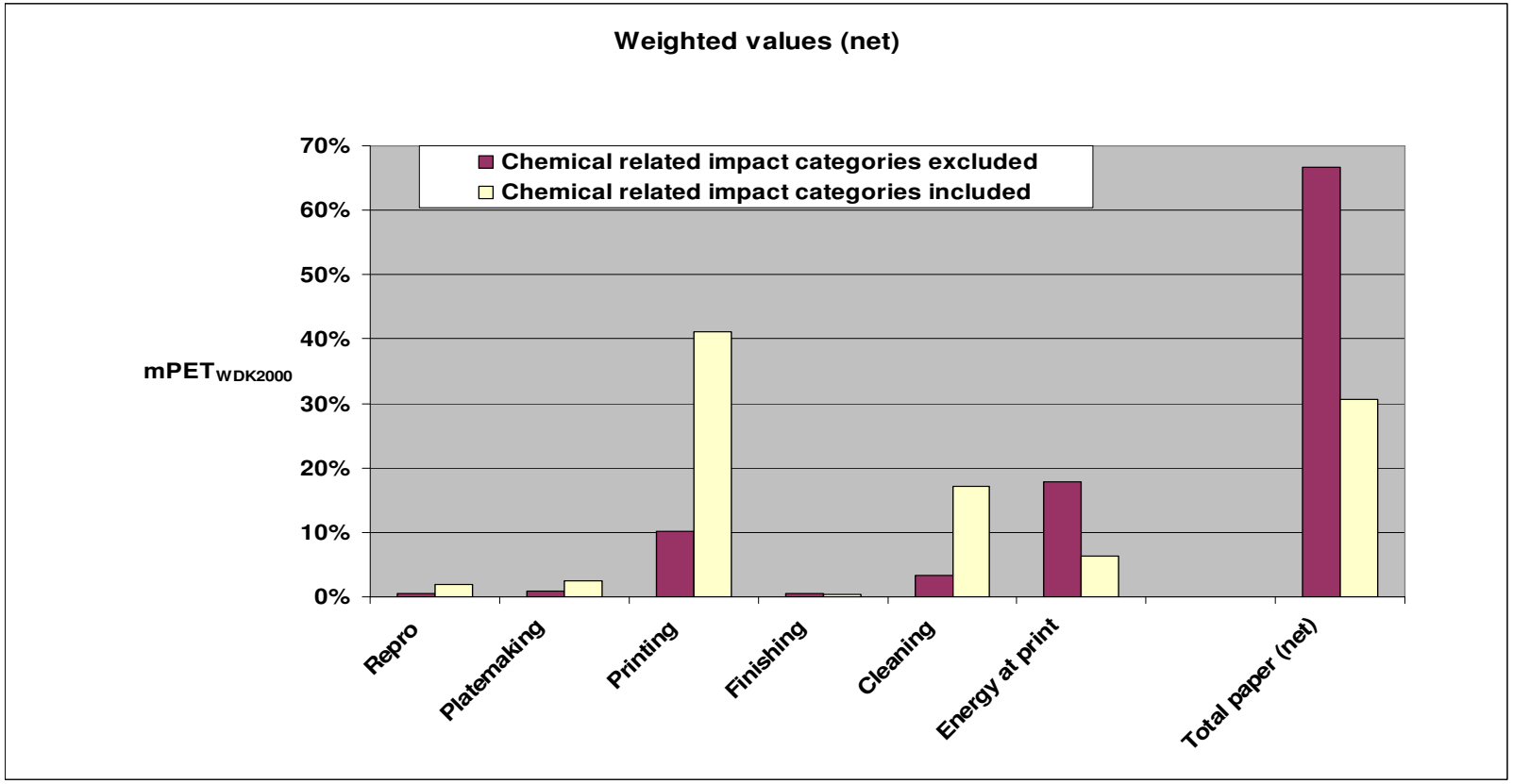
Results
Distribution of resource consumption



Results
Relative distribution of resource consumption



Results regarding environmental impacts
Effect of including chemical related impact categories



Contributions to the sheet fed offset printed matter impact profile

Significant contributing chemical emissions

- Emissions of ink residues (tetradecane) and cleaning agents (hexane, tetradecane) during the printing process and cleaning (35%)
- Emissions (dichlorobenzidine, chloroaniline, cuprous chloride) during pigment production (17-20%)
- Emissions of heavy metals and AOX (as dichloro benzene) during paper production (>3%)
- Emissions of fountain chemicals (i.e. isopropyl alcohol, IPA) during the printing process (6%)
- Emissions of biocides and hydroquinone from the repro- and plate making process (3%)

Conclusions and further research

Conclusions:

- The effect of including the chemical-related impact categories is compared to earlier studies substantial: The importance of paper is reduced from 67% to 31% and the importance of printing increased from 10% to 41%
- Especially the emissions during production of printed matter and pigments are contributing

Improvements/further research

- Better coverage of upstream processes:
  - Ink components (and their precursors) production: siccatives, antioxidants etc.
  - Water emissions from paper production: softeners (BPA), other phenolic compounds (NPE, APE), other surfactants (LAS), biocides (benzothiazoler, dibromo-compounds), wood extractions (terpenoids, resin acids) and more
- Better coverage of downstream processes including recycling:
  - Recycling of paper: Fate of paper chemicals, ink chemicals, glue chemicals etc.
  - Treatment of chemical waste: Fate of (hazardous) waste from printing (ink waste, used cleaning agents, used rinsing water etc.) and from recycling of paper (sludge from repulping
- Including data from recent (2009) substitution-database on chemicals/products used in the printing industry: Includes 588 substances covering more than 1000 products (900 MSDS). 58 substances candidates for the REACH Annex XIV list (potential substances of very high concern, SVHC)

References

- Larsen HF, Hansen MS, Hauschild M (2009). Life-cycle assessment of offset printed matter with EDIP97 – how important are emissions of chemicals? *J Clean Prod 17, 115 – 128.*
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